Marine Option Program Final Report for Internship with the Juvenile Hammerhead Shark Feeding Study at the Hawai'i Institute of Marine Biology Coconut Island, Kāne'ohe Bay, O'ahu

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Kaneohe Bay is an important nursery site for the Hawai'i scalloped hammerhead shark, Sphyrna lewini, *and as such is the perfect site for the study of juvenile hammerheads. Through a number of research projects, students and faculty at the Hawai'i Institute for Marine Biology on Coconut Island in the Bay have sought to learn more about hammerhead and other shark populations.*

One specific study, conducted by Kanesa Duncan, a zoology Ph.D student, addressed the issues of ration size and the efficiency of energy conversion in juvenile hammerheads. As a field assistant on this project I conducted basic duties including feeding of sharks, maintenance of tanks and equipment, and recording of scientific data. Throughout this project I worked to achieve several goals including: (1) to gain experience in a marine science setting; (2) to meet people in the marine field; (3) to learn more about scalloped hammerhead shark behavior and biology; and (4) to gain experience collecting scientific data.

Through my experiences on the island I achieved all these goals and more with an excellent learning experience overall. In addition to the scientific skills and in-depth knowledge of shark biology and ecology, I gained many long-term transferable skills and some personal insight.

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Background and Goals

Scalloped Hammerhead Sharks are among the most widely studied sharks in Hawai'i, particularly in Kāne'ohe Bay on O'ahu. These sharks, known taxonomically as *Sphyrna lewini*, are commonly found both as adults offshore and juveniles in sheltered areas. Kāne'ohe Bay in particular has been a popular location for hammerhead study, due both to the convenient location of the Hawai`i Institute of Marine Biology on Coconut Island within the Bay and the Bay's function as a nursery site.

Scalloped hammerheads, which spend most of their adult lives offshore in deep water, use shallow, sheltered areas, such as Kāne'ohe Bay to give birth. During the summer months, adult hammerheads move in to the Bay and give birth to litters of 15-30 pups (Taylor, 1993). These can be seen in the Bay throughout the year, although they are most abundant between April and October. Juveniles are 15-18 inches long at birth and feed mainly on small fish and crustaceans. As many as 10,000 pups are born each year in Kāne'ohe Bay (Clarke, 1971).

Because of their obvious abundance in the Bay and the unique nature of the area, researchers over the years have taken advantage of the opportunity to study different aspects of the juvenile hammerheads and Kāne'ohe Bay's important role as a nursery site. Some of these studies on juvenile *Sphyrna lewini* include work on electroreception, feeding ecology, population genetics, and several growth and aging studies.

Currently, the main ongoing project examining the juvenile scalloped hammerhead population in Kāne'ohe Bay is a study entitled "The Effect of Ration Size on Growth and Gross Conversion Efficiency of Young Hammerhead Sharks, *Sphyrna lewini*". This research study, headed by Kanesa Duncan, a UH Mānoa Zoology Ph.D candidate seeks to examine small populations of captive juvenile sharks and how their feeding habits relate to overall growth. The study has been ongoing for over a year.

As previously mentioned, there have been studies done on juvenile hammerheads relating to age and growth. One specific study, conducted by Christopher Lowe, analyzed average energy use for juvenile hammerheads. It also studied caloric intake needs for survival in the Bay (Lowe, 2002). This current study, while similar in scope to Lowe's work, differs in that it is studying captive hammerheads and analyzing their growth over time as it relates to the percentage of their body weight in food consumed. In addition to the growth information gained from keeping the sharks in captivity in a controlled feeding environment, studying them closely and for long periods of time allows for a better understanding of behavior and the environmental and water quality needs that may affect growth and health (such as water temperature, salinity, and pH).

Furthermore, Kanesa Duncan, who heads the hammerhead study, is a participant in the Ecology, Evolution, and Conservation Biology's graduate program in K-12 education. As such, she works with local high schools doing both in-class educational sessions on marine ecology and outreach on Coconut Island. Various schools have participated in the study, including Mililani High School, Castle High School, and Upward Bound students. These students are

allowed to gain hands-on experience with a scientific study by going to Coconut Island and participating in the shark feeding and data collection. The program gives these students a significant opportunity that they otherwise may not have been able to experience.

As a Field Assistant on this project I had specific duties relating to data collection, observation, and maintenance. Before starting my work I created several goals that I hoped to achieve during my time on the shark study. These included the following:

- To gain experience in a marine science setting;
- To meet people in the marine field;
- To learn more about scalloped hammerhead shark behavior and biology;
- To gain experience collecting scientific data.

These proposed learning objectives were intended to be fulfilled by completing my everyday tasks for the project. While I was there and involved in the shark feeding study I was constantly exposed to a marine science environment and what it is like to work in a marine laboratory. Coconut Island was a particularly interesting place to experience this since it is an island dedicated to marine research.

Methods and Materials

The juvenile hammerhead feeding study was an ongoing project which involved the capture of six hammerhead sharks that are below the age of one year. The sharks were held in tanks at Coconut Island for a period of four weeks. The first week of captivity was an acclimation period during which the sharks were fed a portion of 3.5% of their body weight each day. After that initial week of acclimation, the experiment began. During the experiment period all the sharks were fed different portions – different percentages of their body weight, or simply as much as they could eat. How much was eaten by each shark was logged down by volunteers (like me) during the one or two daily feeding periods (morning and/or afternoon). The shark was weighed at the initial capture and again upon release. These data, in addition to the daily amount eaten, were the main data collected from the project and were used for research purposes.

During my time interning with this hammerhead shark feeding study, I was responsible for completing a number of activities relating to the study, but was not actively involved in the research aspects of the project. The activities I completed mainly included fishing for sharks, feeding the sharks, keeping data on sharks, and monitoring and maintaining the shark tanks cleanliness and water quality.

Fishing for sharks was the first part of any experiment cycle. The fishing was usually done from two boats anchored between Coconut Island and Lilipuna Pier during early to mid-afternoon. During the winter months, fishing was occasionally conducted farther out in the Bay to ensure better catch. Hand lines fitted with barbless hooks and baited with frozen squid were let over the side with the bait dangling several inches above the bottom. When a shark was caught it would be brought slowly up to the surface and onto the boat. The hook was immediately and carefully removed and the shark was placed on a padded

measuring board where its length was recorded and its fins were clipped for identification. The umbilical scar was checked to determine age, and then the weight was recorded by attaching rubber bands around the sharks head to weigh with a hanging spring scale. The shark was then held in the "bubble" (a half sphere filled with sea water) and transported upside down in a state of tonic immobility[1] back to the laboratory tanks.

Feeding sharks was done every day, twice a day during one period of the experiment and once a day during another period of the experiment. I was responsible for feeding two to three times a week. I removed all bones and skin from the frozen fish and cut the flesh into small pieces. The food was weighed in tared containers and the weight recorded. Then the sharks were divided into individual areas of the tank using weighted nets to separate them and fed their portions individually. The food was given to them over the course of twenty to thirty minutes. The remaining uneaten food was then removed, reweighed, and recorded to determine the amount consumed. The dividers were removed and the tanks were recovered to protect the sharks from the sunlight (as they are usually live in deep water they are prone to sunburn) and help keep the tanks free from algae growth.

In addition to the food weights, other scientific data were collected every time I worked with the sharks. Daily I tested the water temperature, pH, salinity and dissolved oxygen content. These data were the core of Kanesa's research and had to be meticulously taken. Particularly, all measurements of food ration – both before and after feeding – had to be accurate. Beginning weights and lengths and ending weights and lengths also had to be accurate as this was essential to determining growth patterns. Essentially, without these data there would have been no point to the research.

In addition, behavior and any distinguishing markings or budding health problems were noted. There were actually numerous unexpected issues that came up during the project leading to occasional deaths among the hammerhead pups. . When a shark was found dead, it was removed from the tank and data were kept on it as well. Weight was recorded and tagged on the shark before it was frozen. These deaths allowed us to further explore the sensitive balance between hammerhead pups and their environment. I was involved in discussion on why they may have died and an 'experiment within an experiment' that we conducted to test environmental conditions

Maintaining tanks was vital to the health of the sharks and the ultimate success of the project. Before catching a new batch of sharks both tanks had to be cleaned thoroughly, the filter backwashed, and the tanks refilled and prepared for new inhabitants. At every feeding, the filter was backwashed and rinsed to ensure that it was functioning as it should. The tanks themselves could not be cleaned very thoroughly while the sharks were in them, but as sediment built up on the bottom, a siphon was used to remove some of it. This was done after every feeding to clean up excess food and sediment.

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[1] When a shark is inverted it enters a natural state of paralysis. This state, called tonic immobility, is often used for shark handling, since the animal is dull and unresponsive

During the course of my internship throughout all these activities, I was learning some of the basics of a scientific experiment, data collection, working with a team in a scientific setting, and the problems that come with keeping live animals. I was able to gain some hands-on experience with an ongoing research project, and while I was not actually doing research, I certainly came to understand what was involved in putting together a project of this magnitude, including time, planning, volunteers, technical support, and monetary support. I was also taught by Kanesa about shark feeding styles, the specifics of the Kāne'ohe Bay population, the relationships between adults and juveniles, and other general behavioral characteristics and had the opportunity to be exposed other shark research ongoing at HIMB. This included some of the current work being done with electromagnetic reception in juvenile hammerheads, as well as research being conducted on sandbar sharks, black tip and white tip reef sharks, rays, and tuna.

Personal skills such as time management and organization and better interpersonal skills were definitely gained. I had to ensure that in addition to my regular work and classes I was spending enough time at the internship and getting everything done. Working both with Kanesa and a group of volunteers also encouraged me to develop better interpersonal and communication skills. Ultimately many of these skills can be transferred to other work and projects, even those that are not scientific in nature.

Results

Because the project has been ongoing for several years and was not complete upon my departure, I am unable to present the outcome of those years of research. Since this was the study of Ph.D research it is necessarily long and complicated.

During my stay on the project I did learn a lot about the feeding patterns of sharks and some of the basic data. To date the experiment has shown that the experiment hypothesis is true that sharks need a ration of 3.5% of their body weight to maintain their weight. How much more is needed to facilitate growth at different rates, is still to be determined. One of the major difficulties of the project to date has been getting the sharks to eat above 3.5%.

Aside from the main research project, however, there was a secondary experiment conducted during my time as a field assistant. This experiment made up most of the work done whilst on the project. During my first round of shark research, three out of the six sharks we caught died in captivity. All others were released in the hopes that they would survive in their natural environment. Because of this, however, no data were collected for the feeding study. This problem, however, did give us a new 'experiment within an experiment' to conduct. Because it was suspected that the poor environmental conditions within the tanks were causing the deaths in the sharks, a protein skimmer was procured and added to one of the tanks. Six new sharks were then added to the tanks and put on an "all you can eat" diet. The purpose of this shark experiment was not to gain information for the feeding study, but to gain information on whether or not a protein skimmer was an effective tool for creating a better environment. The

protein skimmer was placed on only one of the tanks and daily measurements of the water were taken. Dissolved oxygen content, temperature, and pH were recorded for both tanks. By comparing these data over the weeks as well as monitoring the health of the sharks in the different tanks we were able to see whether or not the protein skimmer was a useful item.

Over the course of the weeks, the data showed that dissolved oxygen content was consistently higher in the tank without the skimmer, while temperature was consistently lower. These differences, while constant, were only slight. The measured pH in both tanks remained relatively constant.

While this environmental data were limited, the observed behavioral and health changes in the sharks was obvious. The sharks in the tank with the protein skimmer were obviously more energetic with healthier appetites. There was little to no bacterial growth on their skin or any other visible health problems. The water in this tank was clearer and cleaner.

The sharks in the tank without the protein skimmer suffered numerous health problems over the course of the month. While at first they had fairly good appetites and energy levels, their health seemed to diminish over time. All three sharks developed bacterial infections on their skin, had severely reduced appetites, and were generally sluggish in the water. One of the sharks developed a serious eye problem and had to be released. Another had a severely reduced food intake until it eventually stopped eating and I found it dead in the tank. The final shark was released with no obvious health problems. Upon release or death, however, all sharks were weighed and their weights compared to the original catch weight. None of these sharks had gained weight and two out of the three had lost weight.

Discussion

From the experiment with the environmental conditions it is easy to see that the protein skimmer had an immense and obvious effect on the health of the young sharks. Because hammerheads have difficulty adjusting to different environments and are especially sensitive to algae blooms and the presence of other water contaminants, the added cleaning action of the protein skimmer aided in a better environment for the sharks. It would be beneficial to have the protein skimmer in both tanks to ensure that future feeding experiments were more effective.

What this project really revealed, at least to me during my time there, is how little is known about the environmental sensitivities and requirements of these sharks, and probably others. Further research projects could be developed to solely address these questions. By learning more about the specific environmental requirements of a test animal, not only would you gain information on the requirements of the shark – a useful exercise in itself – but you would have this information available to use for studies such as this feeding study.

Had information been available on the optimal environmental conditions needed for young hammerhead sharks, the feeding study could have been prepared better and been more efficient in achieving its proposed goals. These health problems would not have been a setback that we would have had to work

through. Further we would not have conducted the experiment with the protein skimmer which further set back feeding study experimentation sessions. Overall almost 2 months were spent either working with dying and unhealthy sharks or conducting this second experiment. Throughout this time little to no data were gained for the actual feeding study.

Evaluation of Learning

I had a truly excellent experience working on this project with Kanesa and the sharks. As it was undertaken later in my college career it did not really impact my choice of an academic major or my class choices, although it may have an impact on the direction my post-graduate education will take.

I found it both fascinating and fulfilling to work with something so hands-on. While it was definitely fun to work with the sharks, the type of work I did allowed me to really absorb information and skills more effectively than I ever have in the classroom. The project itself was pretty much a reminder of how much I love working with anything to do with the ocean and specifically how much I enjoy working hands on with animal subjects. I loved the atmosphere and Coconut Island and wish I could have the opportunity to do more work out there. I did realize, however, that although I loved working on the research project, I am not sure that research is a path I personally would like to take. Working with the high school students was especially meaningful for me, and has encouraged me to pursue my interest in marine environmental education. I would love to be able to share my knowledge and interest in the ocean environments and species with others. It is very satisfying work.

I also realized more and more that I like working closely with one or two other people, rather than in a very large group for most projects. The exception to this is when I am in charge. In both my current job and in most groups I tend to take the role of a leader, which I enjoy. I work well by myself as well and do not need close supervision. If I know what I am doing I do not hesitate to get started and work and do extra work if needed. I do ask a lot of questions, however, which may or may not be a good thing – depending on who you ask! While ultimately I do prefer working in a group of two or three, some tasks require the work of a larger group of people in order to be completed effectively. In these kinds of situations I usually tend to take a quieter, more passive role – something I am not always comfortable with, but which is often just easier to do.

Through both my basic duties with the hammerhead sharks, conversations with Kanesa Duncan, my main resource for shark information, research for this proposal and final report, and experiences with other research projects on the island, I gained extensive knowledge on hammerhead sharks. Specifically I learned a great deal about hammerhead ecology and biology, facts on the Kāne'ohe Bay population and the importance of the Bay as a nursery, different shark research methods and types of other shark research going on at HIMB.

I certainly gained lots of shark knowledge and have hopefully improved my report writing skills as well. I definitely gained more scientific skills, particularly in using some different tools such as a dissolved oxygen meter and protein skimmer. I now have a better understanding of the purpose of these tools and

their inner workings. The development of my time management skills was definitely impacted by this internship. While I was already swamped with things to do, the added task of the project really took me to my limits. Many mornings I was required to get up at 5am just to make it to Kāne'ohe and back before my morning classes. It was a definitely good exercise in discipline.

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